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The influence of invertebrates on the development of Algae

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With 5 figures

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1. Introduction

In the course of IBP-activity investigations have been carried out on the relationships between different groups of soil organisms. Henceforth, there has appeared a number of works on interrelations between invertebrates and soil algae (Ština and Nekrasova 1972, Nekrasova i Domračeva 1972, Pivovarova 1972, Počienė et al. 1972, Atlavinytė and Počienė 1973, Heal and Felton 1970, Yeates 1971, Schwabe 1973 etc.).

The question is of a special interest because algae dwelling in surface soil layers are potential phototrophs-producers of biogeocoenosis and the fate of the organic substance formed by them may be similar to phytoplankton transformations which are the beginning of trophic chains in waterbodies.

The interrelations of organisms, in particular, those of algae-producers and animal-biotrophs [feeders on living materials], are much complicated in soil. Higher plants are the main source of the organic substance here and a soil surface as a special biogeocoenotic horizon due to its heterotrophy serves as a habitat not only for a great number of different species but also for the majority of elementary ecosystems. Thalli and separate cells of soil algae are often found to be centres in the formation of more or less resistant microbic associations; it can be explained by the intravital extracellular excreta and, on the other hand, by the creation of mucilaginous indusia capable of absorbing and retaining a great quantity of water. Therefore, algae proliferations are abundant in bacteria and often accompanied by fungi and various invertebrates. The phythophage [algae feeding] organisms appear to refer to different trophic groups — biotrophs, excretotrophs and saprotrophs.

In the present paper an experimental part of which was made by K. A. Nekrasova and L. I. Domračeva and L. S. Kozlovskaja the following questions are discussed: (1) intensity of utilization of algal organic substance by different invertebrates; (2) effect of feeding on the dynamics of algae; (3) role of invertebrates in algae dispersal; (4) indirect effect of invertebrates on the processes stimulated by algal vital activity.

2. Material and Methods

Algophage animals were separated from algae proliferations collected in natural conditions Food selectivity was investigated in laboratories by making up biocomponent associations of algae cultivated on membrane filters on agar nutrient medium of some animals.

Stationary field plots in the neighbourhood of Kirov were used for the estimation of qualitative dynamics and biomass of algae and their production. We have also made use of special artificial constructions — biometria-boxes-with wooden walls, bottomless, their square being 50 × 80 cm². They were filled with screened, well mixed soil. The soil from the experimental plots sod-podzolic, medium-loam with *p*H 5.1 (salt extract).

Samples for an algae registration were taken at a depth of 0—5 cm by generally accepted method (Gollerbach a. Ština 1969) with a simultaneous determination of temperature and humidity of soil. The amount of algae in all experiments was estimated by the method of a direct count with the help of luminescent microscopy. Algae biomass was determined. The biomass was estimated by the indices of cell volume. In order to get statistically true results we used eight replicates.

Methods for the separate experiments will be given below.

3. Role of algae in soil invertebrates feeding

It has long been known that a great number of soil invertebrates feed intensively on algae similar to those in reservoirs. Sometimes such examples were found in cultivation of soil algae when the latter were quickly destroyed by amoebae, infusoria, nematodes and Tyroglyphidae mites developing in cultures (Richter and Orlova 1928; Venkataraman 1961; Nekrasova 1971, 1972; Shtina and Nekrasova 1972). Observations in nature have also shown the relations between invertebrate development and algae, protozoans with diatoms (Zasuchin et al. 1927) and with other groups of algae (Lichovidov 1973), amoebae of the *Hartmannella* sp. with unicellular greens (Pivovarova 1972), Nematoda and rotifers with algae of different groups (Birch and Clark 1953; Bunt 1954; Yeates 1971); oribatid mites with green algae of the type *Protococcus* (Luxon 1972). While studying the ecosystems formed on volcanic rocks, Schwabe found amoebae, infusoria, rotifers and Nematoda of the gen. *Diplogaster* in the surface layer consisting of algae of the genus *Chlamydomonas*. Under luminescent microscopy their intestines showed red luminescence of chlorophyll. Nematoda remained in films until all the algae were eaten.

In storage cultures of soil algae there always occurred different invertebrates, such as amoebae, Infusoria, rotifers and Nematoda filled with algae. According to our observations not only protozoans and Nematoda but also many species of Collembola, oribatid and tyroglyphid mites, and Enchytraeidae, earthworms, millipedes and larvae of some soil dwellers, i.e. representatives of micro- and mesofauna too are feeding on algae. Thus, films of nitrogen fixing blue-green algae in humid state were quickly destroyed by larval Tipulidae and Sciaridae. So, there are very many examples of algae eaten by soil animals. But they did not give an indication of the amount of food eaten. Therefore algae requirement dimensions by different groups of animals were determined in our experiments. It was noted, for example, that amoebae ate unicellular green algae at intervals of 15 minutes, algae cells being absorbed almost immediately.

Table 1. The intensity of eating various algae species by Enchytraeidae

Algae spp.	Duration of the experiment	Number of worms at the end of experiment	Amount of algae eaten by one worm per day	
			1000 cells	MG a.d.m.
Chlamydomonas reinhardii	16	54	37 ± 2.5	3.1×10^{-3}
Chlorella terricola	13	29	319 ± 15.8	4.1×10^{-3}
Scotiella nivalis	17	49	11 ± 2.9	1.2×10^{-3}
Nostoc muscorum	17	62	103 ± 19.5	2.2×10^{-3}
Actinochloris sp.	16	35	13 ± 2.2	2.8×10^{-3}
Control (sterile soil)	17	6		

Experiments with Enchytraeidae on membrane filters with different algae species grown on them have indicated the number of algae eaten by one individual per day (table 1).

The experiment was photographed while algae were eaten and its duration was not the same in different variants. All the algae investigated were eaten by Enchytraeidae, but in various quantities. As far as biomass is concerned, *Chlorella* sp. and *Chlamydomonas reinhardii* were eaten more intensively. However, the rate of algal reproduction also depended on the quality of food: all the algae stimulated reproduction (in the control there were only six left in sterile soil at the end of the experiment). The process was more rapid in feeding on *Chlamydomonas reinhardii* and *Nostoc muscorum*, much slower — in feeding on *Chlorella*.

An intensive reproduction with abundant laying of eggs and cocoons was found on algae films only for Enchytraeidae. Tyroglyphidae mites and some species of Collembola (fig. 1) and it was not observed for other animals.

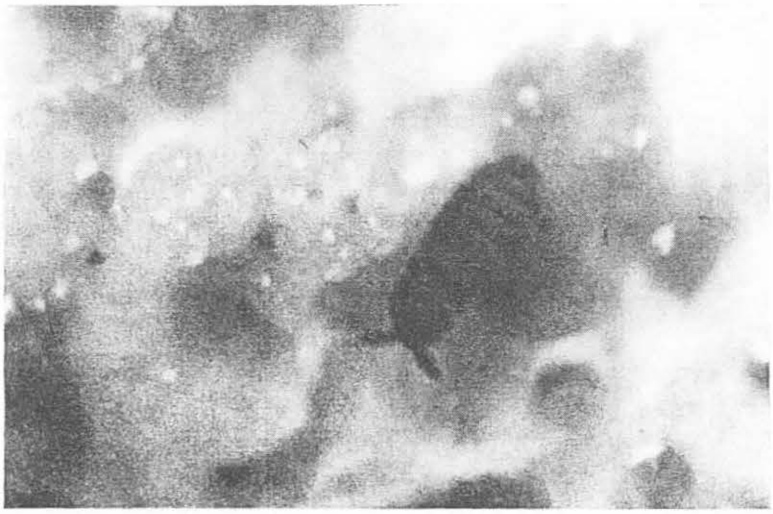

Fig. 1. A clutch of Collembola eggs on layers of algae.

Heal and Felton (1970) stated that only three algae species from 40 investigated sustained the reproduction of *Acanthamoeba* sp. All *Acanthamoeba* sp. had fed selectively. Thus, small amoebae *Hartmanella rhysodes* preferred blue-green algae (*Nostoc* spp.) to green and yellow-green ones, and large-sized amoebae and Tyroglyphidae mites showed preference in consumption of green and yellow-green algae (table 2).

Selective feeding was also shown by Diplopoda. Millipedes, *Sarmatiulus kessleri* were actively feeding on *Scenedesmus quadricauda*, *Chlamydomonas reinhardii*, *Nostoc muscorum* 137, but they rejected *Anabaena cylindrica*, *Nostoc muscorum* 21 (fig. 2).

It can be suggested that sometimes algae cells do not serve as food for soil animals but that they feed on mucus surrounding them and associated bacteria. Thus, the intensive reproduction of amoebae, infusoria and Nematoda was found in algae films which were not eaten by them.

According to the methods developed by L. S. Kozlovskaja, the fate of algae has been studied after their passage through earthworm intestines *(Lumbricus rubellus* and *Octolasium lacteum*; and *Sarmatiulus kessleri)*. The schema of the experiment involved the determination of algae composition and their amount in the food source, in different parts of the intestines and in excrements. Food material (peat — in case of earthworms and birch litter-fall — in the experiment with Diplopoda) was inoculated with algae: peat — by means of *Chlorella vulgaris* suspension, birch litter-fall — by that of *Nostoc muscorum*. After daily feeding the animals were dissected and algal composition and quantity were estimated. Apart from introduced algae in intestines and excrements the autochthonous algae of peat and litter-fall occurred.

Table 2. The intensity of algae consumption by invertebrates

Type and species of algae	Amoebae		Enchytraeidae	Tyroglyphidae
	largesized, non-ident.	*Hartmanella rhys.*		
Green:				
1. *Chlorella terricola*	+++		++	+++
2. *Chlamydomonas reinhardii*	+++		+++	+
3. *Scenedesmus quadricauda*	—		+	+++
4. *Actinochloris* sp.	++		+++	—
5. *Scotiella nivalis*	++		+	++
6. *Coccomyxa* sp.	+++		++	+++
Yellow-green:				
1. *Pleurochloris* sp.	+++		+	++
2. *Chlorocloster pachychlamus*	++		—	+++
3. *Characiopsis* sp.	—		—	+++
Blue-green:				
1. *Phormidium inundatum*		+++	—	—
2. *Nostoc muscorum* 21		+++	—	—
3. *Nostoc muscorum* 25		+	—	—
4. *Nostoc muscorum* 137		+++	—	+
5. *Anabaena cylindrica*		++	+++	—
6. *Tolypothrix tenuis*		++	+	+

Note: (+) Rate of feeding, (—) Algae are not eaten.

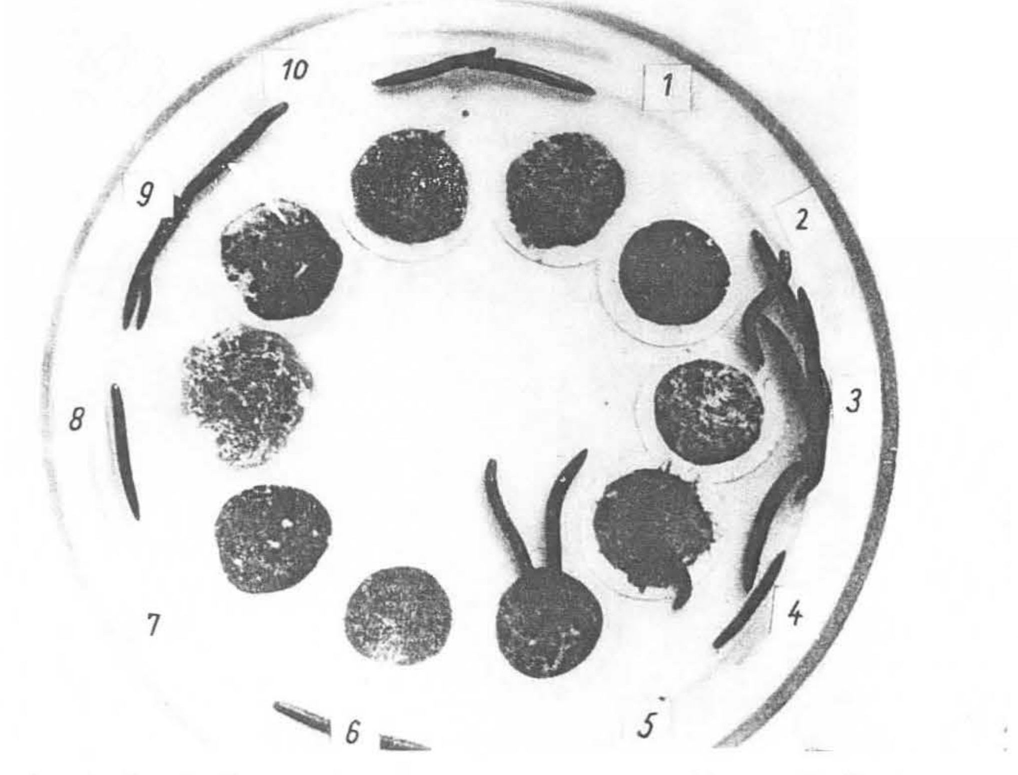

Fig. 2. Diplopoda selective feeding on algae: (1) *Chlorocloster pachychlamus*, (2) *Nostoc muscorum* 21, (3) *Scenedesmus quadricauda*, (4) *Chlamydomonas reinhardii*, (5) *Pleurochloris lobata*, (6) *Actinochloris* sp., (7) *Chlorella minutissima*, (8) *Nostoc muscorum* 137, (9) *Hormidium flaccidum*, (10) *Anabaena cylindrica*.

The algoflora of the intestines was found to be much poorer than that of substratum. Thus, thirteen species from eighteen occurring in peat have been found in the excrements of *L. rubellus*. The respective ratio for *Octolasium lacteum* is: 7 species in excrements and 12 in peat. Consequently, some part of algae in intestines is digested. According to the quantitative check-up the largest amount of algae was revealed in the substratum (tables 3, 4, 5).

Table 3. The number of algae in litter-fall, intestines and excrements of millipedes (1,000 Ex./g, absolute dry matter)

Algae groups	Litter-fall	Anterior part	Posterior part	Excrements
Green and yellow green algae	2,197 ± 107	41.8 ± 6.7	536 ± 73	1,311 ± 80
Diatom	39 ± 4	13.4 ± 1.8	23.8 ± 1.8	58.7 ± 5.3
Nostoc muscorum	7.901 ± 333	77.5 ± 3.8	2.226 ± 40	2.674 ± 507

If we compare the algae content in different parts of the intestines in millipedes and earthworms (table 3, 4, 5) we can also see that the digestion of algae takes place mainly in the anterior part of the intestines where the lower absolute amount and percentage of living algae cells were found in comparison with the middle and rear sections. A high content of algae in excrements (table 3) shows that a complete digestion does not take place even in feeding on preferable algae species.

Table 4. Number of algae in peat and intestines of earthworms (1,000 cells/1 g of absolute dry matter)

Algae groups	Peat	Anterior part	Posterior part
Green algae	4.646 ± 582	157.6 ± 12.6	407.5 ± 8.2
(incl. *Chlorella vulgaris*)	3.428 ± 476	69.4 ± 8.8	274 ± 8.2
Blue-green algae	84.6 ± 4.3	—	—
Diatom	29.6 ± 1.4	1.0 ± 0.1	3.4 ± 0.2

Table 5. Number of living algae (1,000 cells/1 g absolute dry matter) and their ratio in the total amount of algae in millipedes intestines

Algae species	Parts of the intestines					
	Anterior		Middle		Posterior	
	Number	%	Number	%	Number	%
Chlorella vulgaris	2.135	—	105.228	—	250.573	—
Hormidium flaccidum	2.582	*14.9*	3.722	*16.9*	9.290	*33.7*
Pleurochloris magna	593	*41.1*	5.210	*51.9*	20.476	*60.0*

It can be said that part of the invertebrate fauna should be looked upon as animals with the mixed type of feeding utilizing higher plants residues (saprotrophy) in addition to living planta — algae (biotrophy). Apparently, feeding on soil algae, especially on their proliferation on the soil surface, replenishes animal's need for energy-rich materials as well as vitamins. According to Barašhkov (1972) calorific value of 100 g organic matter makes up: for Cyanophyta 441, Chlorophyta — 472, Bacillariophyta — 525 cal. Different vitamines have been found in algae cells.

Naturally, the results of laboratory experiments are difficult to extrapolate referring to natural conditions. But it can be assumed that active consumption of soil algae occurs also in nature and that algophage animals are regulating the algae density in soil under natural conditions.

4. The influence of feeding on the dynamics of algae density

It is known that algae biomass estimated by a direct weight or any calculated method varies in soil between 20 and 1500 kg/ha (Gollerbach and Ština 1969). The annual production is to be much higher if the rate of algae reproduction and their organic matter introduced into trophic chains should be taken into account.

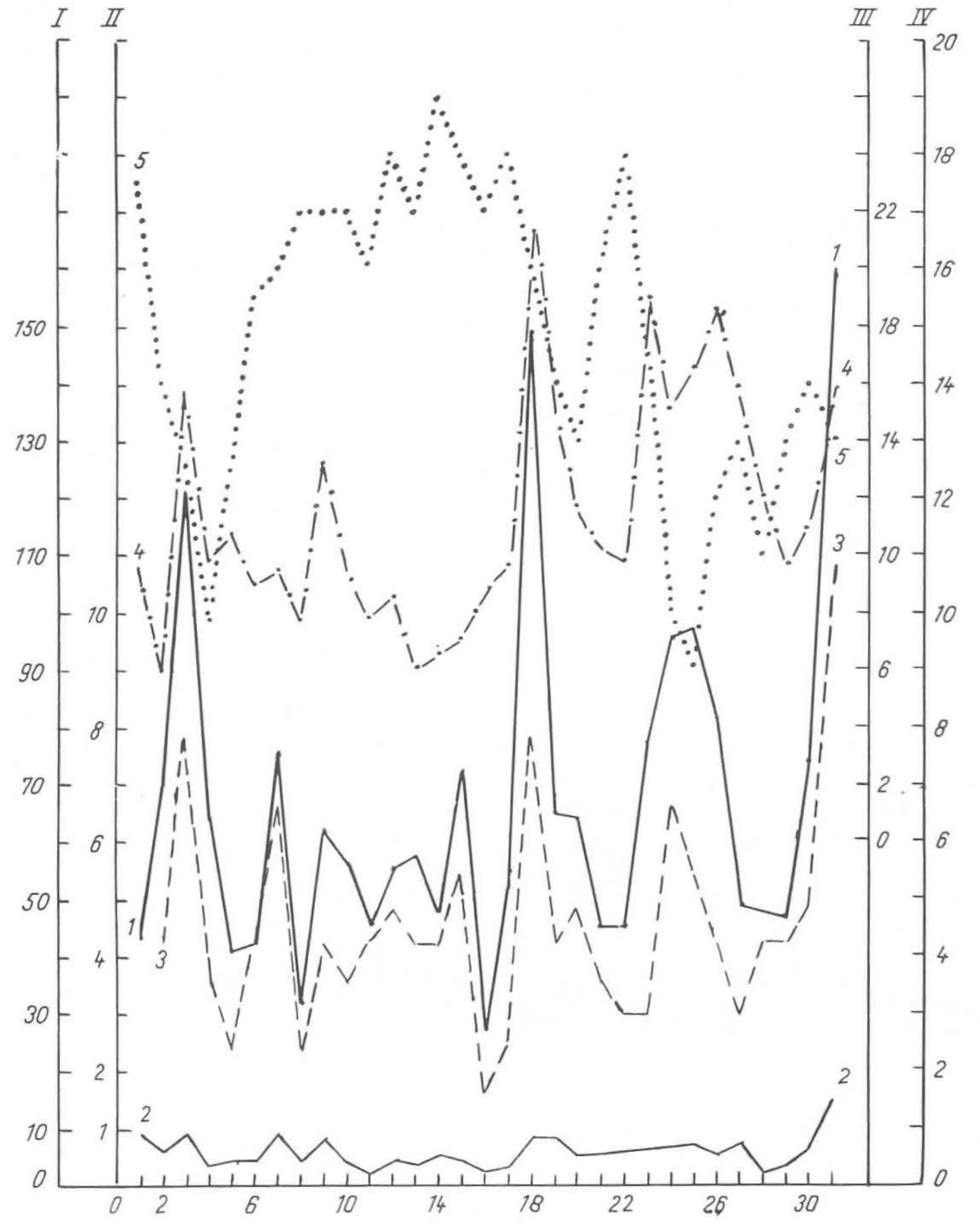

Fig. 3. The dynamics of algae in soil of biometers (August 1971). (I.) Quantity of algae (1000/g), green and yellow-green (1), diatoms (2); (II.) Biomass of algae (kg/ha) (3); (III.) Soil moisture in % (4); (IV.) Soil temperature (5).

Рис. 3. Динамика додорослей в почве биометров (август 1971). I — количество водорослей (тыс./г) — зелёные и желтозелёные (1), диатомовые (2); II — биомасса водорослей в кг/га (3); III — влажность почвы в % (4); IV — температура почвы (5).

In order to determine the primary algae production, daily dynamics of algae in soil has been investigated (Domračeva 1972, 1973, 1974; Ština et al. 1974). In sod-podzolic soil disposed in special biometres which were placed in the field, also in similar soil of a waterless meadow there were found drastic fluctuations of algal quantity and biomass (fig. 3, 4, 5). Considerable increasing of biomass to 7-fold could be observed in 24 hours and its drop was also very rapid (fig. 3 and 4).

A correlation analysis showed during dry periods the algae development is limited by the water availability in soil (a coefficient of correlation r = 0.85). After rainy periods with soil moistening the algal reproduction is drastically increased and their biomass. But

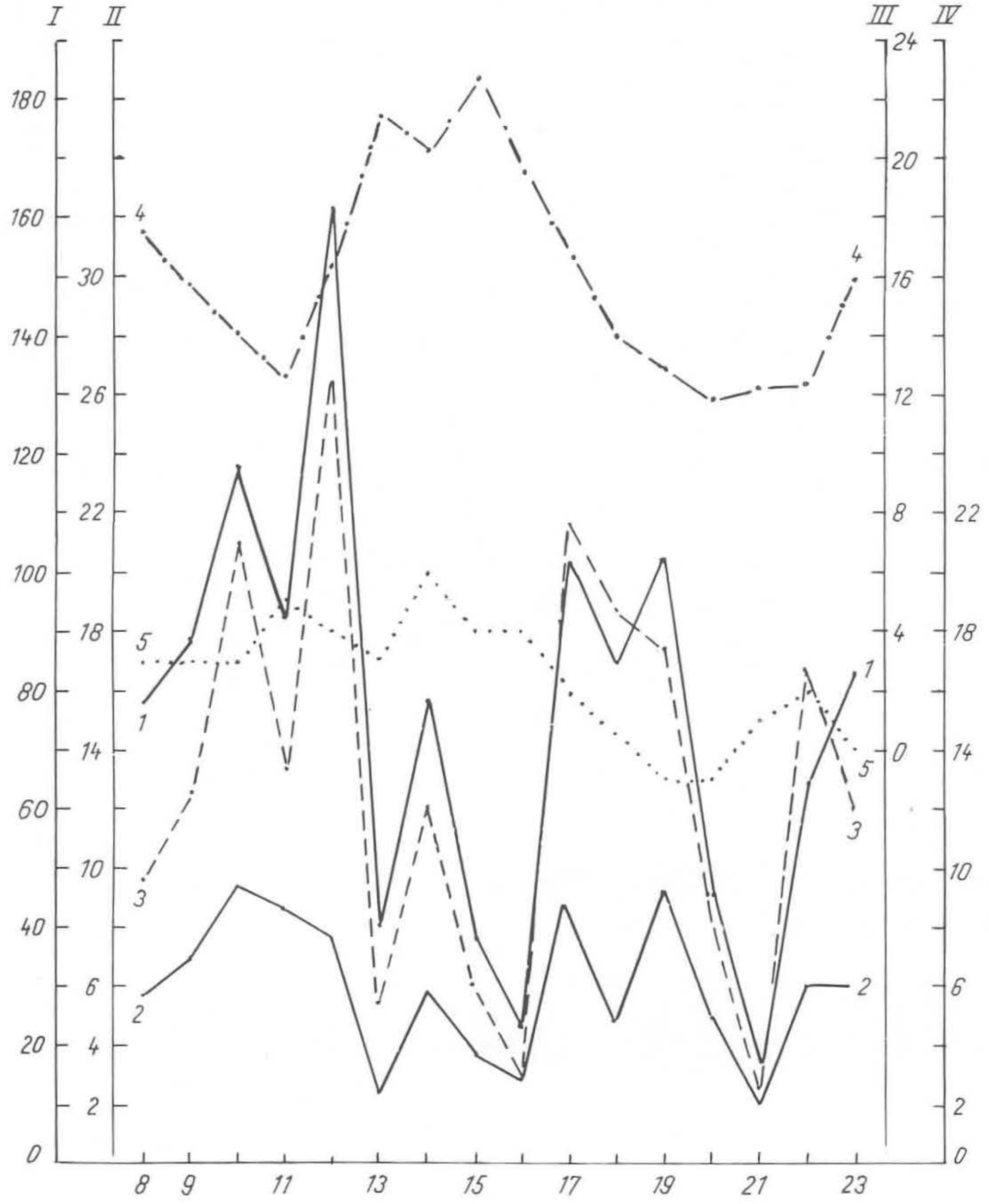

Fig. 4. The algae dynamics in grassland soil (July 1972). (I.) Quantity of algae (in thousand per g), green and yellow-green (1); diatoms (2); (II,) Biomass of algae in kg/ha (3); (III.) Soil moisture in % (4); (IV.) Soil temperature (5).

Рис. 4. Динамика водорослей в почве биометров (август 1973. I — количество водорослей (тыс./г) — зелёные и желтозелёные (1), диатомовые (2); II — биомасса водорослей в кг/га (3); III — влажность почвы в % (4); IV — температура почвы (5).

then under rather high humidity a sudden decrease occurs (fig. 3, 4, 5), which can be explained only by ceonotic factors, firstly be consumption of the reproduced algae cells. When moistening is sufficient, the correlation coefficient for biomass fluctuations with humidity falls to 0.64—0.40 and the algophages activity advanced. Under these conditions the time for a generation of soil algae population, i.e. the period of doubling their amount varies between 12 and 60 hours and their seasonal production increased many times over (up to 32.000 %) instantaneous indices of their biomass. Such a high dynamics of algae quantity and their biomass is beyond question evidence for intensive inclusions of algae organic matter into trophic chains in soil.

Taking into account above mentioned scales of algae consumption by many invertebrates as their main food or "vitamin supplement" algophage animals can be considered

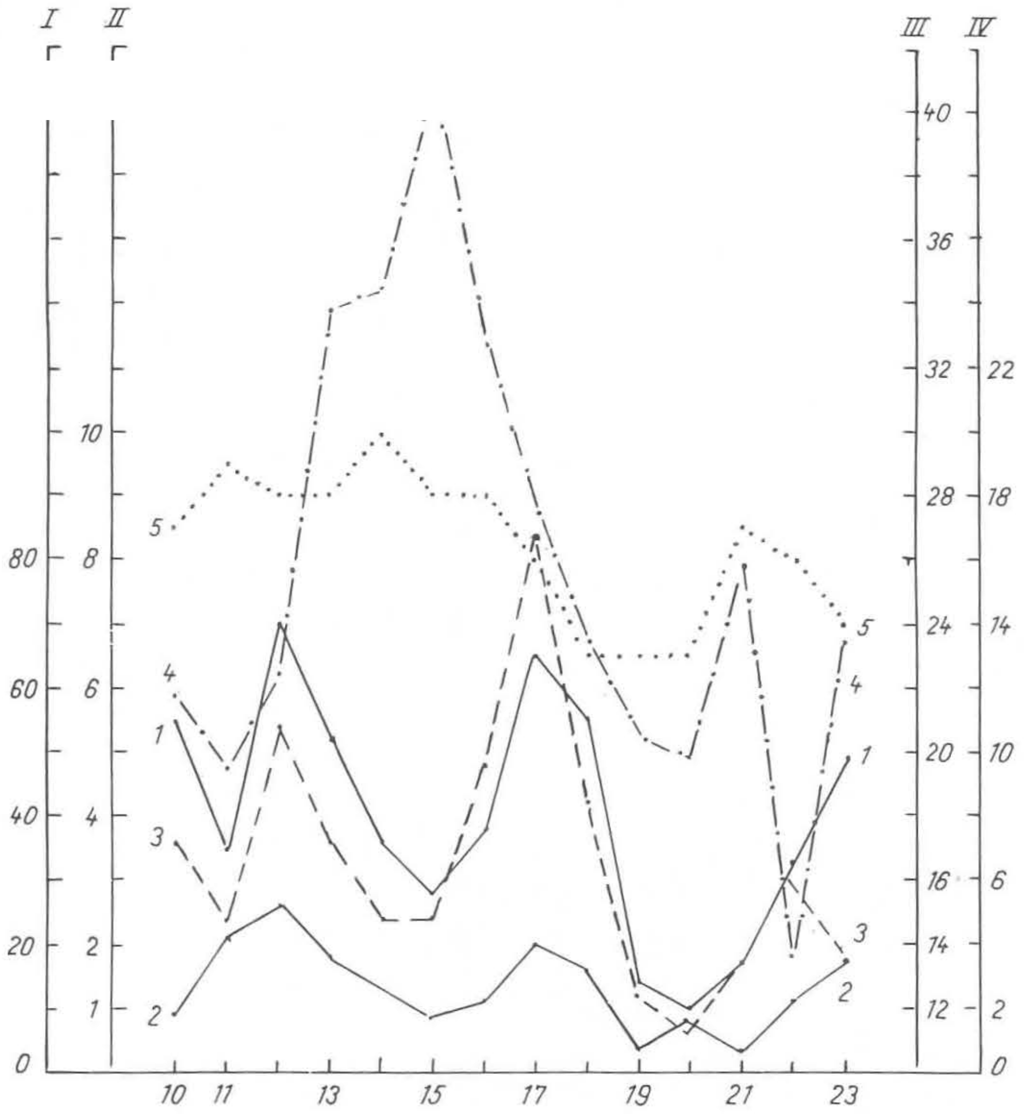

Fig. 5. (I.) Quantity of algae (in thousand per g), green and yellow-green (1); diatoms (2); (II.) Biomass of algae in kg/ha (3); (III.) Soil moisture in % (4); (IV.) Soil temperature (5).

Рис. 5. Динамика водорослей в почве луга (август 1973). I — количество водорослей (тыс./г) — зелёные и желтозелёные (1), диатомовые (2); II — биомасса водорослей в кг/га (3); III — влажность почвы в % (4); IV — температура почвы (5).

to be an important factor which regulates the amount of algae in soil. Soil invertebrates appear to play the main role in the transportation of algae organic matter, as far as the autolysis of dying cells or their bacterial destruction seems to occur much slower, according to available data, than the absorption of living cells by algophage animals.

5. Role of invertebrates in soil algae dispersal

Algae could be found at a considerable depth of 2.7 m (POPOVA 1957) though the majority of them can reproduce only in the surface soil layers within the limits of light penetration. It has long been considered referring to the works of ESMARH (1914) that one of the ways of algae dispersal in soil is a transportation by soil animals. LEAK and YENSEN (1970) proved from experiments that Nematoda *Pristiochus heretitieri* living in various algae species left viable cells only of the alga *Ankistrodesmus* sp. in its excreta in such a way dispersing them.

Our experiments have also indicated that there is a certain selectivity in digestion of different algae species by animals. Therefore some of the algae pass through the intestinal canal uninjured and are capable of further active growth. In particular, *Chlorella vulgaris* was found to be such a species resistant to digestive ferments. It was proliferating on the agar medium of the Enchytraeidae excreta and from fine-beaten mites mass of the gen. *Tyrophagus* which had been feeding on the natural algae films where *Actinochloris* sp. dominated.

As it was mentioned above, in the experiments with earthworms and millipedes their excreta had always viable algae. To show that the movement of animals assists in algal dispersal earthworms living in peat and millipedes were extracted from the birch litter. They were carefully washed in order to prevent mechanical contamination of algae and were placed into the same but sterilized substratum. In five days animals were extracted and the substratum was incubated, exposed to the light, moistening it for two weeks. As was estimated, green and diatom algae occurred in the birch litter-fall (11.4 thousand and 7.0 thousand cells in 1 g absolute dry matter, respectively) but *Nostoc muscorum* was not found although it had been inoculated into the litter-fall.

In peat where earthworms were placed there no algae were recorded. But algae were discovered when peat was inoculated on nutrient medium. Their amount in peat appeared to be less than it was possible to reveal by the method of a direct counting.

A similar experiment with transplanting of washed animals into a sterile substratum was carried out with millipedes which were feeding on pure algae cultures, such as *Chlorella vulgaris*, *Hormidium flaccidum* and *Pleurochloris magna*. It was turned out that *Ch.vulgaris* develops out of excreta in abundance and its biomass and amount are more than that of *Pleurochloris magna* but *Hormidium flaccidum* does not develop at all (table 6). Thus, *Nostoc muscorum* and *Hormidium flaccidum* which were found in a large amount in food were absent in the excreta of millepedes, probably because of the full digestion.

Table 6. Algal quantity and biomass grown in the litter-fall out of excreta of millipedes during two weeks

Algae species	Quantity of algae (1,000 cells in 1 g)	Green weight (mg/g)	Weight (absolutely dry matter mg/g
Chlorella vulgaris	3.698 ± 234	0.159	0.048
Pleurochloris magna	17 ± 2.5	0.072	0.031

At the same time the toxicity of some animals for algae was found out. The filters with green and yellow-green algae were placed on the excreta of earthworms, Diplopoda and Sciaridae; Sciaridae excrements were obtained when the latter were feeding on the excrements of Diplopoda. The litter-fall and peat similar to those on which animals were cultivated served as a control (table 7).

Table 7. The influence of invertebrates excrements upon algae

Variants	*Scenedesmus quadricauda*	*Pleurochloris* sp.	*Pleurococcus* sp.
	(Algae yields on filters in relative amounts of suspension density)		
Test I			
1. Birch litter-fall	0.121 ± 0.002	0.072 ± 0.005	—
2. Excrements of Diplopoda	0.123 ± 0.003	0.076 ± 0.005	—
3. Peat	0.055 ± 0.001	0.090 ± 0.003	—
4. Excrements of Lumbricidae	0.038 ± 0.001	0.077 ± 0.004	—
Test II			
1. Excrements of Diplopoda	0.550 ± 0.050	—	0.328 ± 0.063
2. Excrements of Sciaridae	0.133 ± 0.011	—	0.124 ± 0.005
Test III			
1. Peat	0.400 ± 0.006	—	0.150 ± 0.004
2. Excrements of Lumbricidae	0.365 ± 0.026	—	0.124 ± 0.003

The Diplopoda excrements were not found to be toxic for algae though after passing through the Sciaridae intestines they have become toxic. The earthworm excrements have showed a negative effect on algae which have not disappeared even during a long period of excrement storage. According to POČIENĖ et al. (1972) the decrease of algae amount in soil of vegetative pots with increasing of earthworms amount may be explained by the excrement toxicity.

Therefore, invertebrates are actively controlling the composition and amount of soil algae, by decreasing the amount of one type and by spreading the others. Thus, invertebrates have indirectly affected the primary production of biogeocoenosis and those processes that take place in soil due to algae viability.

6. Main aspects of the role of algae in biogeocoenosis

6.1. Accumulation of primary organic matter

It is generally known that algae, being producers of the organic matter, form the first stage of the succession in the biological exploitation of rocks and anthropogenic dead substrata taking part in the primary soil formation (cf. Summary of GOLLERBACH i ŠTINA 1969). An intensive development of algae also takes place in completely formed soil.

In case there is surface algae proliferation presenting a kind of created crust of soil "flowering" algae biomass reaches 1500 kg/ha (GOLLERBACH. ŠTINA 1969). But as shown above, the annual algae production is much higher than that measured during separate periods (fig. 3, 4, 5).

6.2. Molecular nitrogen fixation

Nitrogen-fixing blue-green algae are widely spread in soil, and sometimes they accumulate a considerable amount of nitrogen. Thus, according to PANKRATOVA's data (1974), nitrogen accumulation by algae in soil of water meadow varies from 17 to 18 kg/ha.

6.3. Anti-erosive role — i. e. participation in binding of soil particles and fastening of moving soil surface, sands and ash burrows.

In this process filamentous algae with mucid cellular tunics (*Hormidim* sp.) or with mucose cap (blue-green) are of a special importance. In the surface proliferation of filamentous algae a filament length can reach some tens of metres per cm² (GAEL i ŠTINA 1974). Algae, on one hand, quite mechanically embrace soil particles, on the other hand, glue them together with abundant mucus, thus preventing erosion by the wind.

6.4. Stimulation of biological soil activity

Algae stimulate heterotrophic microflora and general biotical soil activity in different ways: with the help of their living organic excreta, including algae cells into trophic chains of feeding and destruction, also indirectly — through influence on the development of invertebrates. This is one of the main roles of algae in the soil formation.

7. Summary · Резюме

Observations in nature and laboratory experiments have shown a significant influence of soil invertebrates on algal development. Algophage invertebrates which belong to different systematic groups (amoebae, infusoria, Nematoda, Collembola, Enchytraeidae, Oribatidae and Tyroglyphidae Diplopoda, earthworms, larvae of insects) are feeding intensively on algae, decreasing their amount. Because of their selective feeding, invertebrates change the composition of soil algae groups. Sharp variations of algae amounts found by every day observations can be explained only by intensive inclusions of the algae organic matter into the trophic chains in soil. As the autolysis of dying algae cells and their bacterial destruction, according to the available data, occur much slower than observation of living algae cells by algophage animals; the latter, apparently plays the main role in the

transportation of the algal organic matter. An important role of invertebrates in algal distribution in the soil thickness has been also proved by examples of earthworms and Diplopoda. Though, the toxicity of the excrements of some animals was recorded.

Thus, soil invertebrates actively controlling the algae composition and amount in soil exert an indirect influence on those processes which are performed by algae in accumulation of the organic matter, fixation of atmospheric nitrogen, stabilization of the soil surface or substratum and, finally, initiate the biotical soil activity.

Влияние почвообитающих беспозвоночных на развитие водорослей в почве

Наблюдения в природе и лабораторные опыты показывают существенное влияние почвенных беспозвоночных на развитие водорослей. Беспозвоночные-альгофаги, принадлежащие к разным систематическим группам (амебы, инфузории, коловратки, нематоды, коллемболы, энхитреиды, орибатидные и тироглифоидные клещи, диплоподы, дождевые черви, личинки насекомых) интенсивно поедают водоросли, снижая численность последних. Вследствие избирательного поедания беспозвоночные изменяют и состав группировок почвенных водорослей.

Обнаруженные при ежесуточных наблюдениях резкие колебания численности водорослей могут быть объяснены только интенсивным включением органического вещества водорослей в трофические цепи в почве. Поскольку автолиз отмирающих клеток водорослей или их бактериальная деструкция происходят, по имеющимся данным, значительно медленнее, чем поглощение живых клеток водорослей животными-альгофагами, последним принадлежит, повидимому, главная роль в трансформации органического вещества водорослей.

Вместе с тем подтверждается важная роль беспозвоночных в расселении водорослей в толще почвы: некоторые водоросли, в частности Chlorella не перевариваются в кишечнике, например диплопод, экскременты которых стаiозятся инокулятом субстратов, лишенных ранее водорослей. Правда, отмечена токсичность экскрементов некоторых животных.

Таким образом, почвенные беспозвоночные, активно контролируя состав и количество водорослей в почве, оказывают косвенное влияние на те процессы, которые осуществляются водорослями: накопление органического вещества, фиксацию атмосферного азора, закрепляющее действие водорослей на поверхность почвы или субстрата и наконец, стимуляцию биологической активности почвы.

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